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PAPERS READ

BEFORE THE

ROYAL GEOGRAPHICAL SOCIETY.

I.—*Congelation of the Neva at St. Petersburgh, and Temperature of its Waters when covered with Ice.* Communicated by Colonel Jackson, F.R.G.S. (St. Petersburgh.) Read 12th of January, 1835.

The physical phenomena of nature, for the most part general, are found, in various parts of the world, to be greatly modified, and sometimes wholly counteracted, by local causes. To study, therefore, with advantage the laws of such phenomena, and their mode of action, it is necessary to observe them in those places where they act with the greatest energy, and are the least controlled; whence the utmost effects of solar heat* should be studied in the inter-tropical regions of the globe; while congelation and other effects of refrigeration should be examined in the neighbourhood of the polar circles.

St. Petersburgh, though not the most northern of capitals, is undoubtedly the coldest.† Here, then, may the phenomena of cold be studied with the least possible inconvenience; and from this city the learned have a right to expect information on all the facts connected with this branch of general physics.

These considerations have induced me to profit by my residence in the capital of the Russian empire, to observe the gradual congelation of the Neva, in conjunction with the temperature of the atmosphere; as also the temperature of the waters of the river when it is covered with a surface of ice.‡ Many circumstances tend to complicate the problem of the congelation of running waters; and I have thought that my observations might have some interest, either as presenting new facts, or as corroborating such as may be already known, or, finally, as presenting anomalies sometimes more interesting than the regular phenomena themselves.

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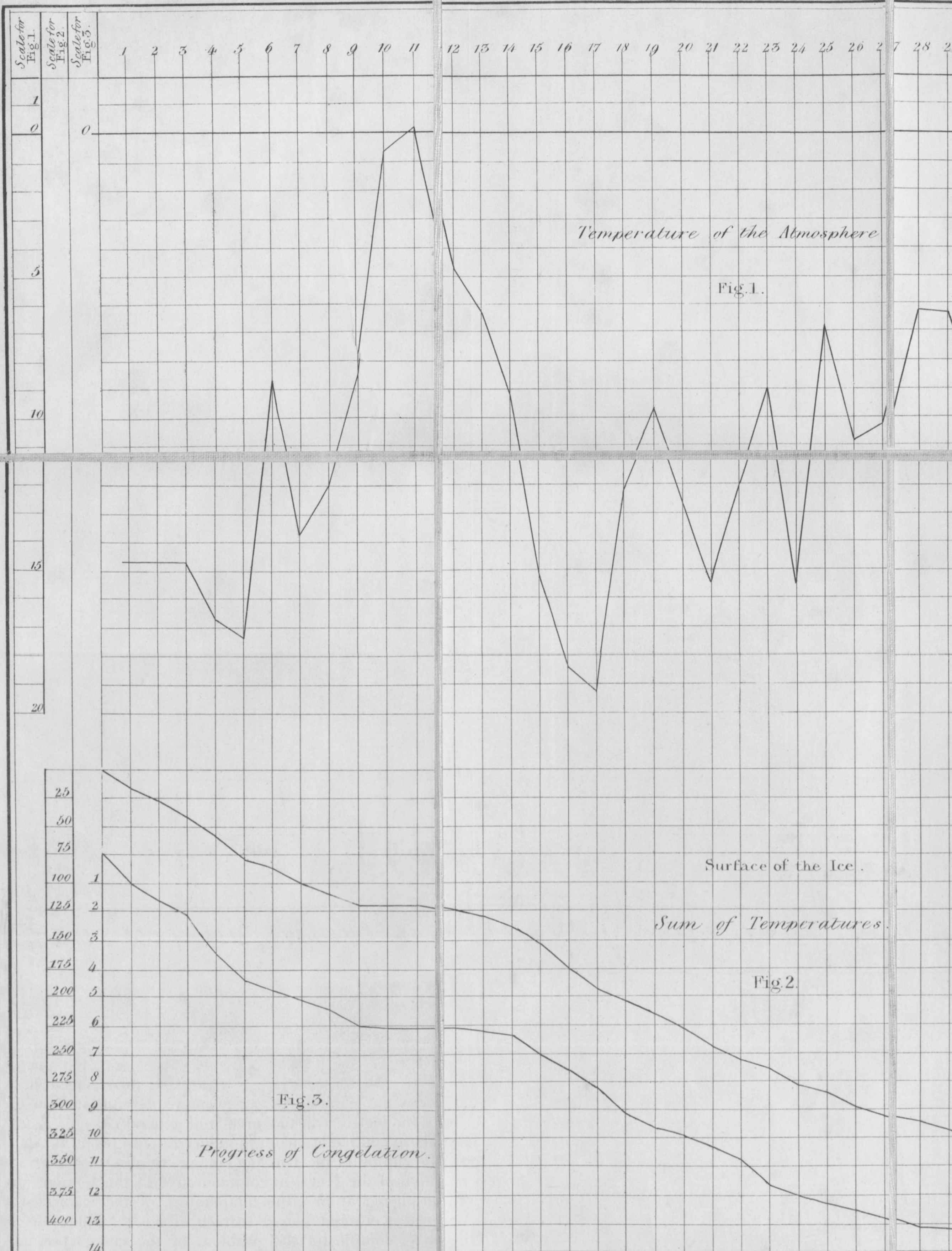
* We must not confound *the effect* of solar heat with the *temporary intensity of the solar radiation,* which is found to be much greater in the northern regions than under the equator.

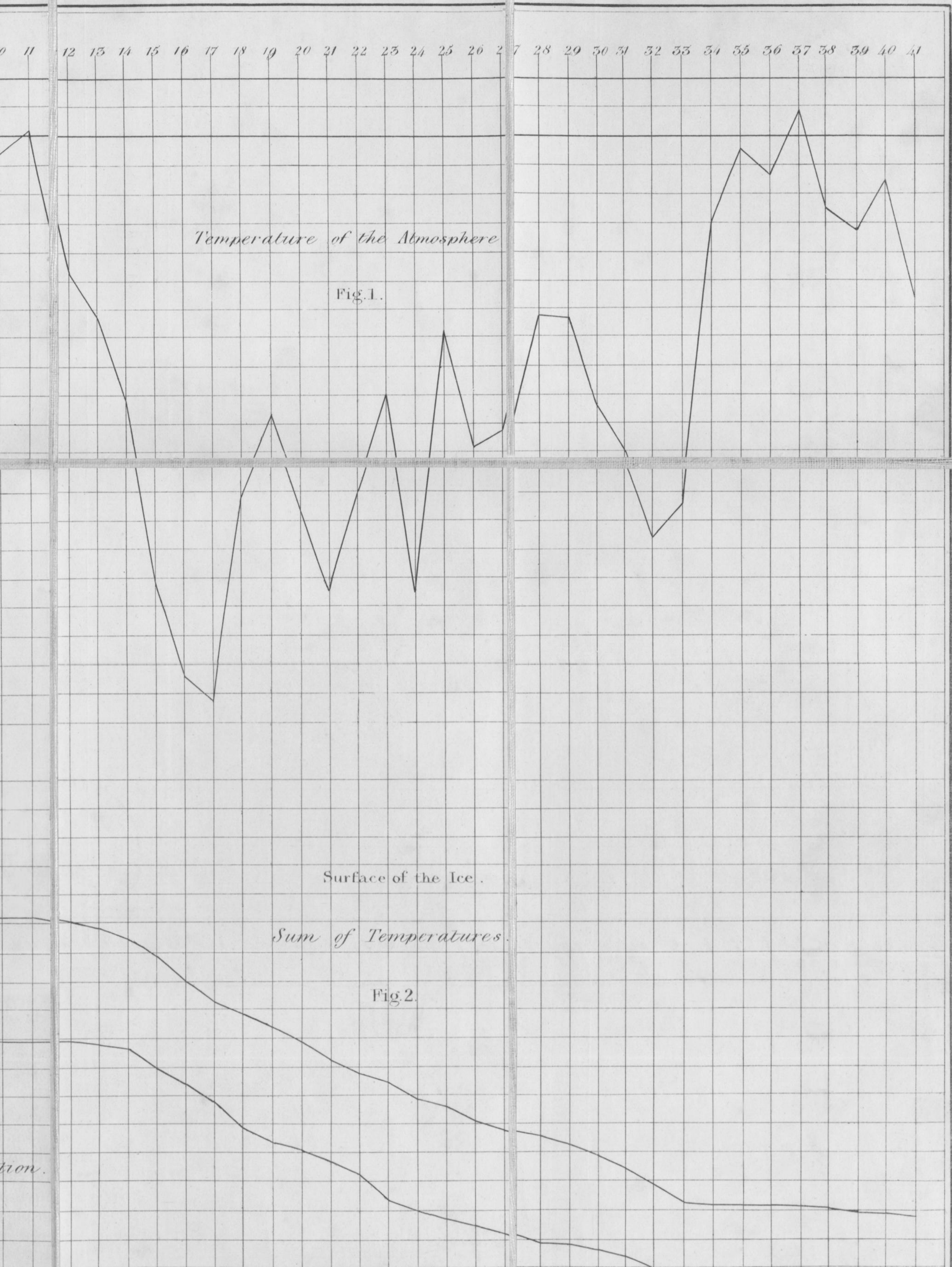
† The mean *maximum* cold at St. Petersburgh is − 24·4 of Reaumur, though it has sometimes come down as low as − 30·2. The mean temperature of the year is + 3°, while that of Christiania, under the same parallel, is + 5°. Drontheim, three degrees more to the north, has a less rigorous climate.

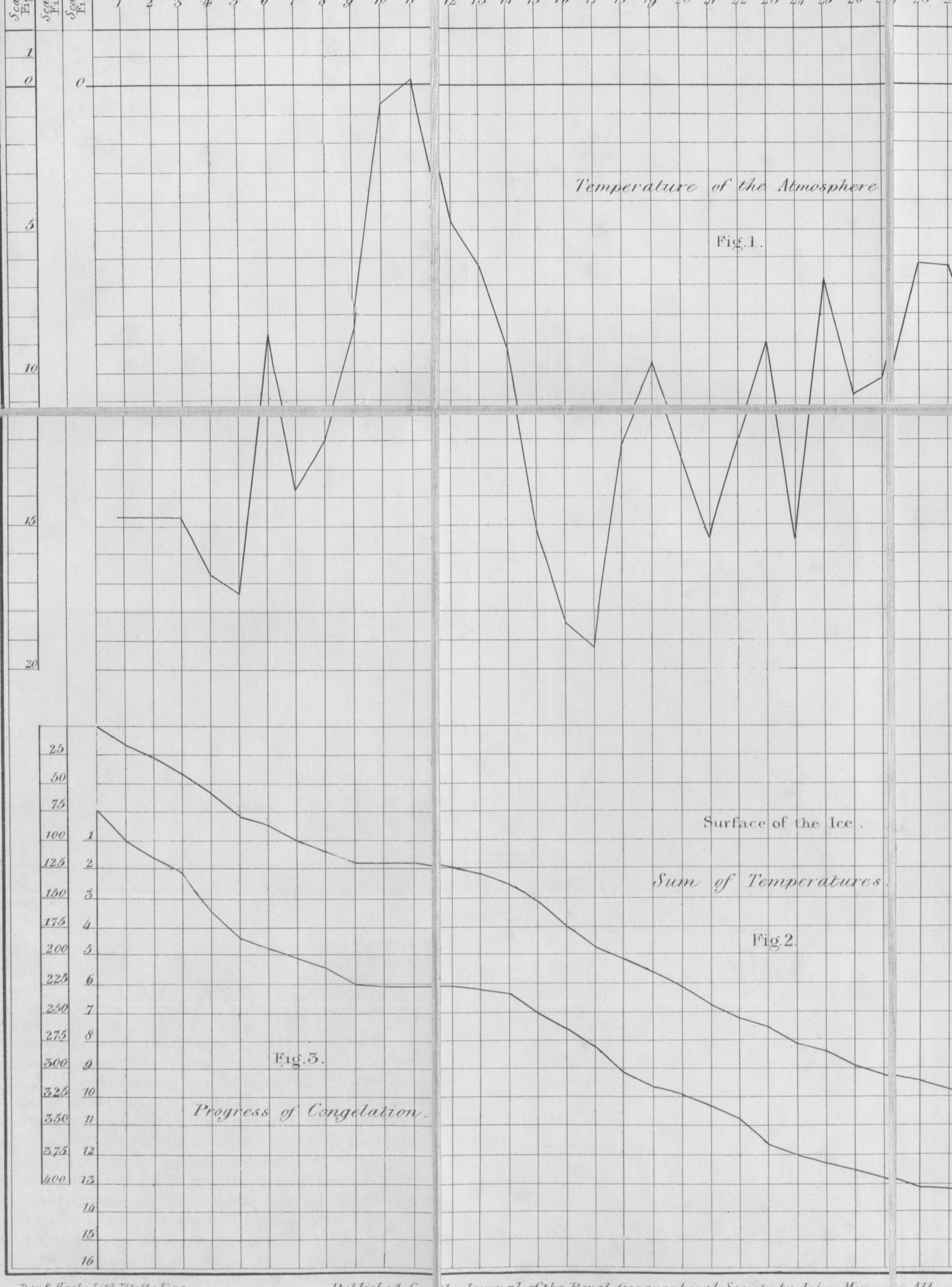
‡ I am not aware that any similar observations have been ever made.

TABLE shewing the temperature and progress of CONGELATIO



rature and progress of CONGELATION at St. PETERSBURG.





Temperature of the Atmosphere

Fig. 1.

Surface of the Ice.

Sum of Temperatures.

Fig. 2.

Fig. 3.

Progress of Congelation.

Day & Haghe Lithrs to the King

Published for the Journal of the Royal Geographical Society by John Murra y Albem

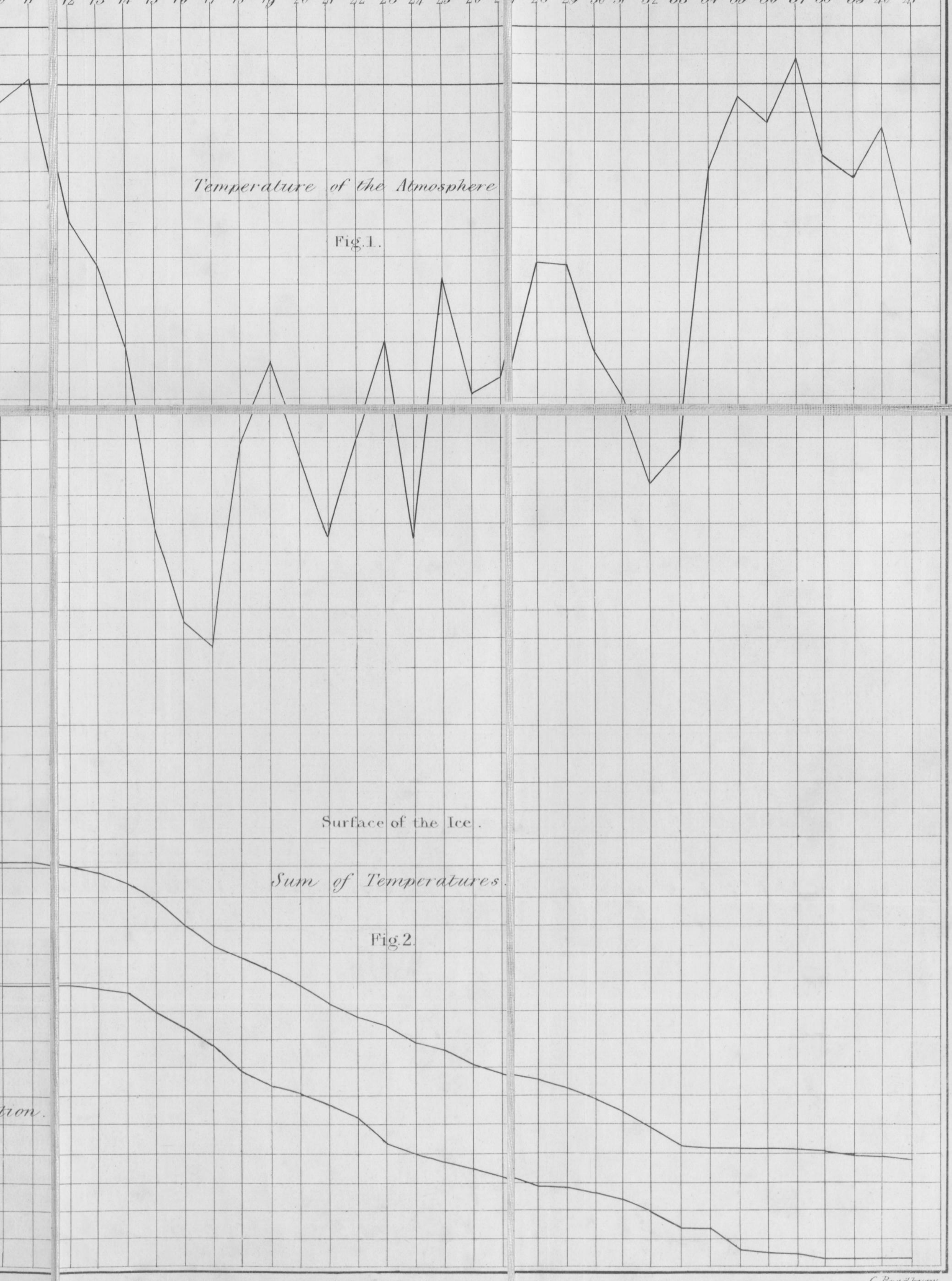


Fig.1.

Fig.2.

ed for the Journal of the Royal Geographical Society by John Murray Albemarle Street 1835.

C. Bradbury.

Previous, however, to a statement of my observations, it may be necessary to remind the reader of the topography of the river.

The Neva, though it be called a river, is more properly a Bosphorus or strait. Its length from Schlusselberg, at the S.W. angle of the Ladoga Lake, to its mouth, is 69 versts;* its direction, that of a straight line from E. to W.; its medium breadth about 1500 feet; and its depth, in many places considerable, is generally, in the channel, about 50 feet. The water of the Neva is remarkably pure, and though the first use of it by strangers generally produces slight diarrhœa, yet it is very wholesome and extremely palatable.

This fine river is the grand and only outlet for the superabundant waters of four great basins, each of which has an extensive natural reservoir of its own. These reservoirs are the lakes Onega, Ilmen, Saïma, and Ladoga; the latter receiving the drains of the other three. Ten different streams flow into the Onega, whose length, from N. to S., is 190 versts; and its breadth, from E. to W., 70. It discharges into the Ladoga by the Sveer, a river 202 versts long and of very unequal breadth, being in some places only 210 feet wide, and in others spreading to a breadth of 2 versts.

The Ilmen is 55 versts long from N.E. to S.W., and about 30 wide from N.W. to S.E. It receives eleven streams, and has its outlet into the Ladoga by the Volkoff, 206 versts long, with a medium breadth of 1400 feet.

The Saïma, which is rather a collection of lakes, of gulfs, and bays of all shapes and sizes communicating with each other, than a regularly formed and single sheet of water, is estimated by Peter Friccius at 130 versts long in the direction of W.S.W. to E.N.E., and 120 from N. to S.; but on the Swedish side, it is about 280 versts more. It pays its tribute to the Ladoga by means of the Voksha or Voxa, a river about 180 versts long, very irregular both in direction and breadth, and not navigable in consequence of its several cascades, of which the most considerable, that of Imatra, has a fall of upwards of 32 feet.

Besides the Sveer, the Volkoff, and the Voxa, the Ladoga receives the waters of thirteen other streams. This, the largest lake of Europe, is about 175 versts long and 105 broad, and of an oval form.

The surfaces of the four lakes are thus estimated—

The Onega . . .	430	leagues of 25 to the degree.
The Ilmen . . .	36	,,
The Saïma . . .	210	,,
The Ladoga . .	830	,,
	1506	

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* The Russian *verst* is 3500 English feet.

From such an accumulation of waters, on which evaporation, however intense the solar heat while it lasts, acts but during three or four months in the year, it is natural to expect an immense outflowing: and accordingly we find the Neva carry into the gulf of Finland upwards of 116,000 cubic feet of water in a second,* a fraction of which proceeds from eight small, though partly navigable, rivers, which fall into it during its course from the Ladoga to St. Petersburgh. The ordinary velocity of the river is about 37 inches per second.

At St. Petersburgh the Neva divides itself into several *deltoidal* branches, the largest of which, at the place where the observations which form the subject of the present notice were made, is 1260 feet broad; and bears along a mass of about 74,000 cubic feet of water in a second, while the Nile, in the same time, furnishes but 21,800 cubic feet.†

That such a body of water, moving at the rate of about 2 miles and 1 furlong in an hour, should be annually covered with a sheet of ice seldom less and often more than three feet thick, while the mean temperature of the air during the winter months is seldom lower than – 4·5° of Reaumur's thermometer, appears surprising; nor could it happen but for the combination of two circumstances, neither of which would be alone sufficient: these are, the drift ice from the Ladoga, and the long duration of the winter.

The drift ice from the Ladoga generally comes down about the middle of November, sometimes in October, and sometimes, though more rarely, not till December. The cold is so sudden and so violent, that twenty-four hours are sufficient to form round the edges of the northern lakes a cake of ice from 2 to 5 inches thick, which is almost as soon broken up by the storms to which these lakes are subject. This event is immediately announced to St. Petersburgh by telegraph. The police are on the look out, and in about twenty-four hours, more or less, the arrival of the first flakes gives the signal for removing the bridges of boats, by which the communication across the river is established. Soon after, large sheets of ice come floating down and announce the setting in of the winter. At this time one of the bridges‡ is frequently removed and replaced, to the great inconvenience of the inhabitants of the capital. Vehicles of every description remain crowded on either bank, while large boats, loaded with passengers, are seen forcing their way through shoals of drifting ice, by which they are often carried down a considerable distance. It is now impossible to replace the bridge, the passage becomes more and more difficult for the boats, and is finally interrupted altogether. Unhappy, then, are those whom affection, business, or pleasure call to the opposite side: the distance is only a few paces, but the passage is impracticable.* This painful suspense lasts a few days, seldom a week.

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* This result was obtained by admeasurement executed with the greatest care and scientific skill by Lieutenant-Colonel Henry, under the direction of Colonel, now Major-General, Destrein, in the year 1826, in order to have the data requisite for devising a means of securing the capital of Russia from the disastrous effects of the inundations to which it is unhappily subject.

† According to the admeasurements of Monsieur Girard, a French engineer.

‡ We say *one of the bridges*, because, although there are several which cross the different branches of the Neva, there are only two over the main trunk, and of these one only can be conveniently manœuvred. The other, from its great length (2730 feet), cannot be so easily managed, and therefore, when once taken away, is not again replaced during the whole winter. The one of which we speak as being frequently removed, termed the Isaac bridge, is on pontoons, and is now manœuvred with

If the lake ice has been broken into small pieces, these sometimes pass on to the gulf without encumbering the river, and when they are all gone by, the bridge is replaced, and things remain as before till the arrival of a fresh batch. If, on the contrary, the flakes are large, they get jammed one against the other, and not only remain fixed themselves, but arrest the progress of the succeeding masses. Between them, however, are large spaces quite clear of ice. In this state, a violent wind is sometimes sufficient again to detach and break the flakes and allow them to proceed, when the river again becomes free. This, however, is not frequent; and, as we have said, when the large flakes fix, the communication is for a while wholly interrupted, not that the ice will not bear, but because of the unfrozen spaces, so much the more dangerous as they are smaller, for then a pellicle of ice being soon formed they become covered with snow and are hidden.

The ice being now firmly fixed, a number of men are set to work to clear away the space immediately below the bridge; it is

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great celerity. Its length is 924 feet, and it is formed of fifteen pontoon boats. This bridge, being cast loose at both ends, swings round against one side, by the current, in about a quarter of an hour, and by means of capstans and warps is again replaced in less than two hours. Formerly the operation of replacing the bridge lasted several days, both in consequence of a defective method and want of skill, and by reason of the bribery employed by the boatmen of the river, who paid in common a considerable sum in order to enjoy the monopoly of the passage across as long as possible.

* The interruption of the communication across the Neva is attended with the greatest inconvenience, for, independent of the ordinary passage to and fro of the multitude in a large city, the Exchange, the Custom-house, the Academies of Sciences and the Fine Arts, the Corps of Cadets of the army and navy, together with other government departments, as also the principal cemeteries, are all in the Vasili Ostroff or island, a kind of suburb of St. Petersburgh, as Southwark is of London. Several circumstances render difficult the establishment of a permanent bridge; the great depth, the ice, and the dock-yard being above the only spot where the bridge could be built. A suspension-bridge has been proposed by Lieutenant-General Bazame, one of the ablest engineers in Europe. His design is truly magnificent, and certainly, if executed, would be one of the grandest monuments of the kind in the world. The property in the Vasili Ostroff would double in value, and the inhabitants of the capital in general, while they possessed the inestimable advantage of uninterrupted communication, would enjoy the proud spectacle of their country's history, traced in the bas-reliefs of metal on the towering supports of the chains, presenting a façade of 104 feet high.

then again swung round and definitively placed for the winter. The large space thus cleared remains uncovered for several weeks, freezing but very gradually from the edge of the ice which surrounds it: a proof that the current is too rapid to be frozen over in ordinary winters* if there were no ice brought down from the lake.

The temperature of the air is now sensibly colder, and in a short time, except in the part we have mentioned just below the bridge, or in any other equally large spot, if such there be, there is everywhere a thickness of ice sufficient for foot passengers, who are now seen crossing the frozen river in all directions. In a few days more the passage is judged practicable for carriages and sledges. Broad roads are then marked off by rows of fir branches stuck upright, and slopes of planks are constructed from the quays to the ice. The river now assumes the aspect of a flat-bottomed valley covered with snow; the carriages, sledges, merchandise, pedestrians, and troops passing and repassing in all directions, excluding the idea of the deep and rapid waters rolling beneath.

This state of things lasts generally about five months, as may be seen by the accompanying diagrammic table, *Plate* 1, in which the periods of freezing and clearing of the river for more than a hundred years past is laid down.

The table, it is presumed, will be easily understood. The vertical lines divide the years into months. The graduation on the two extreme verticals, and on one of the intermediate ones, indicate the years. At every tenth year a horizontal full line is drawn across, and at every fifth a dotted line. From left to right the table contains a period of sixteen months, that is to say, a whole year and part of the next, thus giving the complete circle of months in which are comprised the periods of the river's being frozen over and free from ice.

By following the horizontal line beginning at the year 1720, it will be seen, that the ice broke up in that year on the 11th of April, and that the river remained free till the 7th of November, when it was again covered with ice, and continued so till the 10th of April of the following year, still marked on the same horizontal line, bearing on the right the date of the year 1721. This latter indication is repeated on the left a line lower, where the 10th of April is again found. From it the eye runs along to the 20th of November, between which periods the river remained free in the year 1721, when it was again covered and continued frozen over till the 16th of April, 1722, and so on.

In some places it will be found that there are double indications, as about November from the years 1790 to 1795. They show that the ice, after being fixed, was again broken up, as we have already said happens occasionally.

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* The greater rapidity in this place, owing to the rush of water between the pontoons, no doubt delays still further the congelating process.

The bottom of the table shows when the river is invariably covered or uncovered, and the months in which its change of state occurs. The indications of the table may be thus resumed :—

Breaking up of the ice, and freezing of the Neva for the last 117 *years.*

Month.	Date.		Number of times.	
March	6	1	18	117
	From the 21 to 25 inclusive	4		
	26 to 31	13		
April	1 to 5	18	99	
	6 to 10	28		
	11 to 15	32		
	16 to 20	8		
	21 to 25	9		
	26 to 30	4		
	Freezing of the Neva.			
October	From the 16 to 20 inclusive	3	13	116
	21 to 25	2		
	26 to 31	8		
November	1 to 5	12	95	
	6 to 10	18		
	11 to 15	20		
	16 to 20	20		
	21 to 25	14		
	26 to 30	11		
December	1 to 5	3	8	
	6 to 10	3		
	11 to 12	1		
	14	1		

Hence we learn—*first,* that in the long period of 117 years the ice has never broken up before the 6th March, and only once at that early period; 2ndly, that of 117 times, it has broken up 18 in March and 99 in April, and that the general period is from the 5th to the 15th of April; 3rdly, that it has only frozen once so late as the 14th December; 4thly, that of 116 times, it has frozen 13 in October, 95 in November, and only 8 in December,—and that the general period is from the 5th to the 20th of November; and, 5thly, that, one year with another, the navigation of the river may be said to be free for a period of seven months, and frozen over the remaining five.

Much has been said on change of climate, and there is little doubt but that the establishment of a considerable population in regions before uninhabited must produce local modifications of temperature. The draining of marshes, the felling of forests, and cultivation in general, increase the temperature ; but where the atmospheric phenomena depend in a great measure upon relative position, perhaps even more than upon local influence, this latter will of course be less sensible. At most, local changes in the soil may modify the *degree* of heat and cold, of moisture and siccity, but can have little effect on the *periodicity* of the seasons. And thus, though the climate about the mouth of the Neva may have become milder since the foundation of St. Petersburgh, we have no proof of any change in the periodical return of the seasons or in their duration. Indeed, the table before us is a convincing proof of the contrary, the setting in and breaking up of the winter averaging the same time for the last century. The duration of the winter, we have said, is one cause of the great thickness of the ice at St. Petersburgh. I have seen it 3ft. 6in. ; the drift-ice from the lake being on its arrival 2½ inches.

I was curious to observe the progressive increase as compared with the temperature of the atmosphere, in order to ascertain, if possible, the law according to which the congelation of running water is effected when its surface is already covered with ice. The temperature of the water at different depths, under the circumstance of the river being covered with ice, also appeared to me to be worthy of observation. Unfortunately, the thermometers I had directed to be made by the maker of greatest reputation here were so incorrect and carelessly graduated that I could place no reliance on them, and was therefore obliged to postpone my observations on the temperature of the water. Some time after I learnt that, at the Academy of Science, there was an excellent workman, a Mr. Girgenson, and I accordingly engaged him to make me the instruments I required. He could not, however, begin them immediately, having other work in hand. Other circumstances also prevented my beginning my observations on the progress of the congelation so soon as I could have wished. The ice became fixed this year (1833) on Monday the 20th of November (*old style*), and it was not till the 28th December, O.S.,* that I could begin.

I chose for my experiments a spot in the main branch of the river, at about 200 paces from the south bank, or near the middle of the stream, which in this place is 1260 feet broad. I here caused an opening to be made in the ice, which I found to be 1 foot 4·875 inches in thickness, and the depth of water from its surface in the hole to the bottom, 35 feet. The hole was made in this shape ; the diameter of the round part three feet, and the breadth of the straight part one. Across the end of the latter

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* The Tables Nos. I. and II. are arranged according to the new style.

(thus) a plank, with its surface planed, and being 8 inches wide, 4 inches long, and 1 inch thick, was let into the ice, so as to have its upper surface level with that of the ice. This board, kept constantly clear, was to serve as the offset for my admeasurements, and effectually prevented all those errors that otherwise must have inevitably arisen from the addition at the surface of snow occasionally thawed and occasionally frozen into an icy mass. From the middle of another plank of the same dimensions rose perpendicularly a rod of hard wood, 1 inch square, 4 feet long, and graduated from the plank to the top into inches and eighths of an inch, having this figure . This gauge being let down into the hole lengthways was brought along the neck of the opening and close against the offset plank; it was then turned so as to have its own plank parallel to the offset plank, and perpendicular to the neck or straight part of the opening; it was then pulled up firmly against the lower surface of the ice, while the graduated part was kept in contact with the edge of the offset. The inches were now read off, and gave the thickness of ice between the two planks.

The accompanying table (No. I.) shows the details of forty-one observations, the result of which are graphically represented, *Plate 2*. The table is of itself sufficiently intelligible, the plate perhaps requires explanation.

The numbers at the top are those of the observations, and serve equally for the three figures. The dates corresponding to these observations will be found on the table. Each *figure* has its separate scale marked on the verticals at the left; the first for the first figure, the second for the second, and the third for the third, as indicated at the top. In the *first figure* each vertical division represents 1° of Reaumur's thermometer, and is supposed to be divided into tenths. The mean temperature for the time elapsed between each observation (generally twenty-four hours, unless when accidentally interrupted, as seen by the table) is marked on the verticals corresponding to the number of the observation; and these points being joined exhibit the range or curve of the medium temperature of the atmosphere.

In the *second figure*, each vertical division represents 25° of Reaumur's scale. On the verticals are marked the successive additions of temperature, which being (with two exceptions only) always below *zero*, the curve connecting the several points show the daily additions and sum total of the *cold*.

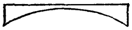
In the *third figure* the vertical divisions represent one inch, supposed divided into eighths. On the uprights are set off the thickness of the ice at each observation, and the curve formed by the junction of these points shows the daily increase and absolute thickness of the ice.

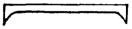
The object of my observations was to ascertain, if possible, the law of congelation of running water; and this law becomes evident by the simple inspection of the plate. The parallelism of the two lower curves, *figs.* 2 and 3, plainly prove that the thickness of the ice is exactly proportionate to the sum of the temperatures, or rather to the accumulation of the cold. The difference from absolute parallelism is so slight as evidently to be occasioned only by the snow with which the ice is occasionally covered, and which secures it against the immediate effect of the cold. On comparing the *third figure* with the *first*, we are not struck with any apparent correspondence, and yet such does exist as far as the nature of the case will allow. Thus, the whole range of the temperature in the *first figure* being *below* zero, the intermediate elevations of temperature can have no effect in *diminishing* the thickness of the ice. Its effects can, at most, be merely preventive of any increase of thickness. So do we find the horizontal parts of the *third figure* corresponding to the greater elevations of the first. Every individual rise in the *first figure* is not accompanied by a horizontal line in the *third*, for the very obvious reason that the temperature of the ice is much slower to change than that of the air; and the former, being considerably below zero, continues to freeze the water in contact with it below. The horizontality of the lower curve can only be effected when the increase of temperature of the air is very great or lasts long. If the increase of temperature be accompanied by a fall of snow, it will necessarily occasion a defect of correspondence between the curves of the *first* and *third figures*, as between those of the *second* and *third.*

What seems most remarkable is, the perfect parallelism of the two lower curves. We should naturally be led to imagine, at first, that a difference in the absolute thickness of the ice would modify considerably the *increase* of thickness for a given temperature. Thus if a given degree of cold, for twenty-four hours, increase the thickness of a mass of ice six inches thick by one inch, it is natural to imagine that the same temperature, for the same length of time, when the ice is twenty-four inches thick, would not increase it anything near an inch; and that, consequently, the *increase of thickness*, for regular increments of cold, would be in a diminishing ratio, determined by the successive thickness of the ice, so that the two curves, instead of being parallel, would converge. This, however, they do not, and the reason probably is, that in the same proportion as the ice thickens by continued cold it becomes itself colder, and thus a parity of action is maintained whatever be the thickness of the ice. If, after each addition of cold and consequent increase of thickness, the whole mass were to re-take the temperature of zero, then it is probable that equal degrees of cold, operating through masses of different thickness, would produce an increase, decreasing in proportion to the thickness the ice had already attained: this, however, is evidently not the case. Moreover, the water in contact with the lower surface of the ice, being at zero, cannot freeze at that temperature by reason of its motion: a still greater degree of cold is therefore necessary, whence it follows that, so long as the already formed ice remains at zero, no increase of thickness can take place; and this reasoning is confirmed by the inspection of the curves. Again, after the increasing temperature of the atmosphere has brought back the temperature of the ice to zero, any fresh increment of cold is, at first, but slowly followed by fresh congelation.

Upon the whole, then, it appears that in running water the process of congelation and thickness of the ice is strictly proportionate to the increments of cold, and that the positive increase of the ice (naturally modified in different rivers by the rapidity of their current) is for the Neva about 1 inch for every 25° of additional cold. The greater or less quantity of snow will further modify the result; but the same causes must ever produce the same effects when not interrupted by like disturbing circumstances. Hence there is, I think, little doubt but that the law, such as we have observed it, is constant; and if observations, similar to those here detailed, were made in rivers of different velocity, so as to arrive at a formula applicable to all cases, the thickness of the ice (the rapidity of the current being known) will give the sum of the temperature from the commencement of the congelation, from which the mean temperature is easily deduced—an object of considerable interest in countries where no meteorological observations can be followed—and, *vice versâ*, the sum of the temperature the thickness of the ice. It is likely that in still waters the same relation of thickness of the ice to the sum of the temperatures holds, but the positive thickness for a given number of degrees will be greater, still water freezing more readily than that which is in motion.

This law of congelation, though the more important, is not, however, the only result of the present experiments. In the course of them, other phenomena have been remarked, which perhaps are not altogether without interest.

1. The cake of ice generally formed on the surface of the water in the hole, being carefully detached from the sides and removed, was invariably found to be concave beneath, thus  that is, the round cake perfectly resembled an immense *plano-concave* lens, a form naturally resulting from the twofold direction of the frigorific action at the surface, and at the periphery of the hole. The concavity was observed to be greatest with a medium degree of cold, for when the cold was too intense, the action at the surface being more rapid than that from the sides,

the whole cake became thicker and the concavity proportionably less. When, on the other hand, the cold was but slight, the cake was thin and equally so everywhere, save quite close to the edge, where it suddenly turned off somewhat in this shape  The temperature at the surface, with the law of progressive congelation downwards being given, as also the inferior or ascertained graduated temperature of the ice of the periphery at different depths, the curve assumed by the lower surface of the cake might be ascertained, but it would be a problem more curious than useful.

The thickness of this cake, as specified in the last column of the table No. I., under the name of *ice formed in the hole,* is the mean between the thinnest and the thickest parts. The indications are in inches and tenths.

2dly. The next observation was a striking confirmation of a fact universally known, namely, the warmth maintained by a coating of snow. If snow fell immediately after the cake of ice had been removed from the hole and was drifted into the hollow (for the water was always a few inches below the surface of the ice of the river) so as to fill it, then, however intense the cold may have been in the 24 hours, not the slightest pellicle of ice was observable on the water on removing the snow.

3dly. The next observation I had occasion to make was that of the formation of a thick bed of snow below the ice and immediately contiguous to it.

In order to account for this, it must be observed that, when the surface of a river is frozen over, its current becomes assimilated to that of water flowing in a pipe, the resistance to its progress being increased by all the friction it experiences against the covering of ice. This friction, though its effect is felt through the whole mass of the vertical section, is sensibly greatest at the periphery of that section, and there, consequently, will the current be the most retarded. Now, if the water be at a very low temperature, though the motion may prevent its congealment into a solid mass, it may be inadequate to prevent a *particular mode* of congelation, which will differ from that observed in still water. Such was precisely the case in the present instance. The water in contact with the ice, and even for a few feet downwards, was found to be invariably at the freezing point, and the motion was sufficiently retarded to admit of its congealment into small flakes of two, three, or more, tenths of an inch in surface, which flakes were loosely agglomerated in a manner very similar to that we observe in the freezing of milk.

While this singular congelation remained under water it was invisible, being altogether transparent, but no sooner was it taken out of the water, than it appeared like snow of a dazzling whiteness, and from the self-same cause.

It is probable that the lower flakes were occasionally removed by the current, and others formed in their place, while the higher ones became less and less exposed as the mass increased in thickness downwards. As to these, indeed, not only they themselves must have remained motionless, but the water between them must have been stagnant. Now the whole mass being at the temperature of zero, it is matter of no small surprise that there could be any *fluid* particles whatever. Yet so it was, and the surface ice of the river increased in thickness infinitely slower (as may be seen by the table) than might have been expected from such a state of things. I see no other way of accounting for this than by supposing, that in order to the formation of *compact ice*, a certain arrangement of particles is necessary, and that the pre-existing arrangement in the flaky mass presents to the new arrangement obstacles which can be but slowly surmounted.

Indeed, the very smooth underside of the surface of the ice when taken up from the river, seems like a confirmation of this conjecture: for if the solid ice were merely formed by a successive conglomeration of the flakes below, then, upon removal of the ice, these would be found adhering to its surface pretty firmly and sticking up in all directions. But, as nothing of the kind is observable, we may suppose that, at whatever time the solid ice may be taken up, it is done at a moment when the operation of a new arrangement of particles is going on, and consequently when there is no adhesion between those already arranged and others in the act of being arranged; at a moment when, as it were, the magnetic axes of the molecules of the one mass, turning round those of the other, come into the perpendicular direction. But I shall no longer dwell upon this occult matter; it may be interesting to the physical inquirer, but seems to stretch beyond the limits of even the physical part of geographical science. Nor would I have dwelt so long upon the subject of this flaky formation, were it not that a similar one is formed (and from the same cause, *viz.* low temperature and a slow motion) at the *bottom* of the river. As well as I could ascertain by the sensation communicated to the hand by the lead-line, the mass at the bottom was not so thick as that at the surface, though it seemed more compact.

There is, I think, little doubt but that in as much as the temperature of the surface of the earth depends upon the temperature of the atmosphere, so that of the soil at the bottom of a river depends on the warmth or coldness of the water in contact with it. If the whole mass of water be at zero, so will the bed of the stream be at zero; and that such is the case in the Neva we shall presently see.

The friction at the bottom might be supposed somewhat greater than at the surface, the bottom having asperities which the surface ice has not; but be it observed, that as soon as a thin bed of the flaky congelation is formed, the friction, in as much as it depends on asperities, is the same at the bottom and at the top. The same causes therefore operating at the surface and at the bottom, the same effect of course results, and as at the top so at the bottom, there is a cake or bed of a flaky congelation: but that at the bottom, pressed by the superincumbent weight of the water, must be more compact, and, both by reason of this mechanical compression and a degree of cold less violent, is also less thick.* Of this snow at the bottom, a part, probably that in immediate contact with the bed, becomes gradually transformed into solid ice, which, if not thawed in the spring at the bottom itself, gets detached and rises to the surface.

This phenomenon is frequent in the Angara, and is not unknown even in the Thames. The circumstance is mentioned by Ireland, in his 'Picturesque Views on the River Thames,' and is corroborated by observations of Dr. Plott, who says, 'the watermen frequently meet the ice meers or cakes of ice *in their rise*, and sometimes in the under side inclosing stones and gravel brought up by them *ab imo*.' I shall not stop to examine the doctor's explanation of the phenomenon, but shall merely observe that the flakes of ice which rise from the bottom of the Angara often bring up in like manner large stones.

The freezing over of a river is by no means necessary to the formation of ice at the bottom. When the whole mass is cooled down to zero, it may, and most frequently does happen, that partial congelations are formed at the bottoms of rivers, while there is no ice at the surface, or merely at the edges. In the sea and in *deep* lakes this cannot happen, because in them the water at the bottom is found to be always *above* the freezing point. But to return to my experiments.

I had originally intended to observe the temperature of the river at different depths, at the same time that I ascertained the thickness of the ice, and expected to find the bottom two or three degrees above zero; and so it probably was for some time after the first fixing of the ice. Unfortunately, however, as I before mentioned, my instruments were not ready; and it was not till the 8th of March, new style, that is 96 days after the fixing of the ice, that I could begin.

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* A third cause for the lesser thickness of the flaky mass at the bottom, and which, it is probable, is even more influential than the very little difference of temperature, may be the lightness of the flakes, which as soon as detached by the motion of the water at the bottom, will rise. Nay, I think it likely that a great part of that which adheres to the under part of the surface ice may have been originally formed at the bottom, from which it has been detached by degrees and risen by its lightness.

The result of 21 observations is given in Table II.; but in order to show what degree of confidence these observations may claim, I shall describe the instrument employed upon the occasion and which I found to answer perfectly. Indeed I may recommend it with confidence to such as may be inclined to make similar experiments.

The object was to have a thermometer which would indicate *exactly* the temperature of the water at the parts where it should be placed, and not alter its indications in passing through strata of different temperatures.

The maximum and minimum thermometer of Six would answer this purpose perfectly, were not the indices liable to be deranged in the motion of pulling up the instrument. Its horizontal position could be easily maintained, but the liability to derangement, thus mentioned, absolutely precludes its use.

The bathometer then occurred to me and I tried it; but soon found that no dependence could be placed on it, both in consequence of the strength of the current which carried it in a slanting direction, and the difficulty of getting it drawn up with that equable and steady motion indispensable to prevent the opening of the valves and consequent admission of water of a different temperature: moreover, in going down it met with the flaky congelations of which I have spoken, a part of which fixing in the valves, prevented their closing, and thus rendered inapplicable, in this case, an instrument sometimes employed with success.

I then caused a thermometer to be made with a cylindrical bulb, eleven lines in length and three in diameter, with a tube of very small bore. This instrument marked with great exactitude the smallest change of temperature. Its range was from -8° to $+40$ of Reaumur's division. The degrees were 15 hundredths of an inch in length, and subdivided into five parts, each of which being ·03 of an inch, allowed me to observe very exactly the half of one of them, or the tenth of a degree, and, with sufficient accuracy, even the hundredths.

This thermometer was now fixed into a cylindrical box of brass one-tenth of an inch thick of metal. The box was four inches high and four in diameter, and the thermometer so placed in it as that the bulb (which had no contact with the metal of the scale) was exactly in the centre. A tube of clear white glass, about one-tenth of an inch thick and an inch and a half in diameter, with a brass virol at one end, was now passed over the exposed part of the thermometer and screwed down air-tight to the top of the cylindrical box. The upper part of this glass tube was also furnished with a virol, into which was screwed a brass cap with a ring to lift up the whole instrument by. This cap had a hole with a cork in order to let in water, and three branches extending to a circumference equal to that of the cylinder at bottom.

In the under part of the cylindrical box was an opening about eight-tenths of an inch in diameter, closed by a plate which screwed into it. By this opening were successively introduced different bad conducting substances, and the sensibility of the instrument was tried with the box filled with air, with water, with eider-down, with charcoal in powder, and with tallow, poured in hot and allowed to cool.

It would be too long and needless in this place to detail all the observations that were made with these five substances: let it suffice, that with the last, *i. e.* the tallow, the instrument required above 11 hours to sink from a temperature of + 14° to zero; and that, being at zero and removed into a temperature of + 18°, it required three minutes to rise the first tenth of a degree.

Now, presuming beforehand that the difference of temperature between the bottom of the river and the surface might be about three degrees, the same change of one-tenth would not be effected in less than 20 minutes, whereas, the whole time employed in raising the instrument from the bottom of the river to the surface (a depth of 35 feet) would scarcely exceed half a minute.

In order still more to prevent the possibility of error, the glass tube in which the visible part of the thermometer was contained was filled with water and hermetically stopped up by the cork; and thus the portion of the column of mercury, which in the tube rose above the brass box, (and which was about an inch in length,) was secured by a thickness of half an inch of water, and one-tenth of an inch of glass, independent of the thickness of the thermometer tube, from the immediate impression of the surrounding medium.

Upon the instrument thus arranged I thought I could rely with perfect confidence; but as an excess of precaution is never a fault in such cases, the whole instrument was put into a cylinder of tin, into which the brass box exactly fitted at the bottom, while the branches at the top kept the whole steady. This tin case was filled with water, and closed so perfectly as to let little or no water escape. The top or lid was a cap with hitches, and was fixed on much in the same way that a bayonet is fixed to a musket.

Round the tin case were rings of iron strongly soldered, two on each side, one near the top and the other near the bottom. A rope was passed down the two on one side, then under the bottom and up the two of the other side and fastened. Thus the whole was slung like the leathern case of a portable telescope. Two other and similar rings were also soldered to the outside of the tin case to receive another and a thicker rope. At the lower end of this thick rope was fastened a weight of 80lbs., which being let down to the bottom remained there; the upper end of the rope, after being passed through the rings of the tin case made to receive it, was fastened to a bar of the inclosure raised on the ice. This weight, with the exception of the two or three first days, remained down during the whole time of the observation, and the rope being stretched was as perpendicular as the rapidity of the current would permit. By this arrangement the thermometer case traversed freely along the fixed rope, and the instrument could be lowered, or raised, or fixed at any depth, with the greatest ease.

There was but one inconvenience, which was the length of time required to leave the instrument in the water, if, on letting it down, its indication was high: but by hiding the ends of the ropes beneath the snow, there was little probability of the instrument being stolen, though hundreds of persons were daily crossing the ice close to it. The indications of the table will show that, fifteen times out of twenty-one, the instrument remained down twenty-four hours and upwards, consequently a much longer time than was strictly necessary.

Before pulling up the instrument, the temperature of the water at the surface was taken, as also that of the air; the instrument was then immediately drawn up, the tin case suddenly opened, and, the brass cylindrical box being still in part immersed in the water of the case, the indication of the thermometer was read off and registered*. It was then let down again, to remain till the next day.

From the Table, it will be observed that there is something like a relation of the temperature of the water to that of the air, the former following the latter after twenty-four hours. The variations are however too trifling, I think, and the number of observations too few, to enable us to conclude anything positive in this respect. The general result is to be taken from the means, and these show that, when the surface of the water has been for some time covered with ice, the temperature of the water in contact with the ice, or at the surface, and for several feet below it, is at the freezing point, or zero; and that, with the single variation of about 0·014 of a degree, at the depth of 21 feet, (which anomaly may, from its minuteness, be an error of observation due to the effect of parallax,) the heat increases downwards until close at the bottom, where it again seems to retrograde. This decrease of temperature at the immediate bottom is evidently owing to the diminished velocity, which favours the formation of the flaky congelation at the bottom, of which we have already said so much.

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* The three thermometers were rendered perfectly comparable by tables of corrections for their slight differences with a standard thermometer.

The difference, however, of the coldest and the warmest part does not amount to 0·06 of a degree, a quantity absolutely insignificant in an experiment of this kind.* During the last observations the weather was getting warmer, and the temperature of the water accordingly oscillated rather above than below the temperature of some of the intermediate observations.

I regret that I was prevented by the circumstances already related from beginning my observations on the temperature of the water sooner, and consequently making a greater number. The twenty-one, however, that have been made suffice to prove, that after the Neva has been for some time covered with ice, the whole mass of water flowing beneath is at zero; for I repeat, the few hundredths above that may be neglected.

When the thaw set in, I was obliged to discontinue my experiments. This occurred on the 31st of March (N. S.), and I caused at the same time a large block of ice to be taken up from the place—on measuring the thickness of which, I found it to be 32 inches. Thirty inches may, I think, therefore be taken as the average thickness which the ice attained this winter (1833-4).

The thickness was not alike in all places. Thus, on the 1st of February, when at the place of my observations it was 27⅛ inches, a hundred paces farther on it was only 16 inches, at another 15, and at a third 22½. But it must be remembered, that the first ice which settles is that which comes from the lake, and this is not only of different thicknesses, but in many places the broken cakes are pushed one over the other, so as to double or treble their thickness, while the spaces between are not frozen, properly speaking, till some days after. The 32 inches, therefore, above mentioned, are not to be regarded as produced *solely* by the cold at St. Petersburgh; I think that 6 inches may be very fairly deducted, leaving 26 inches for the maximum, which thickness the ice would certainly never attain, if the river were not in the first instance covered with that which comes from the lake. Upon the whole, it must be confessed, that though we are at first struck with the great thickness of the ice, yet when we come to examine the subject, we find the progress of congelation rather slow than otherwise; for the very favourable circumstances of an immediate covering in the first instance, and afterwards a constant medium temperature of —3°·5 for 120 days, produce only an average daily increase of two lines.

When to facts such as these we compare the statements of authors who have spoken of severe winters, we confess, that in our utter inability to explain the prodigious effects of which they speak, we are unwillingly reduced to the painful alternative of doubting the correctness of the statements. Thus we find in a work by M. Mann, entitled 'Mémoires sur les Grandes Gelées,' page 45, that, "in the year 763, four months' cold, from the beginning of October to the beginning of February, froze the Black Sea to a distance of 100,000 paces from the coast; and that the ice was 30 cubits thick, and covered with a bed of snow of 20 cubits, the whole forming a solid crust 50 cubits thick!" For this fact M. Mann quotes the Byzantine authors, and, after them, Briet, Lenglet du Fresnoy, &c. He also states, that in the winter of 1363-4 the Rhone was said to have been frozen to the depth of 15 feet; and that, in 1709, the Meuse, at Namur, was frozen 5 feet, the cold lasting ten weeks. Now considering the climates of the Black Sea, and the southern latitudes of the Rhone and of Namur, as compared with the latitude of St. Petersburgh, cold, sufficient to have produced effects such as are here stated, must have been intense beyond conception.

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* It is probable the difference would be considerably greater if the water were deeper; as it is, it coincides with the observations made in the Polar Seas, where the water is *warmer* as you descend.

I should perhaps now conclude these observations, which have been insensibly lengthened beyond what I originally intended, but I cannot possibly refrain from saying a word on a phenomenon as beautiful in its effect as interesting in its progress.

The last ice which comes down from the Ladoga, on the breaking up of the river, is invariably composed of vertical needles, so slightly agglomerated as to be separated on the least percussion. I at first concluded this to be ice formed in some particular situation, either above some soil emitting gas in abundance, or perhaps among the eddies and falls of Imatra, whence it was brought into the lake by the current of the Voxa, and finally passed into the Neva. Attentive research, however, has convinced me that it is nothing more than a natural and spontaneous process of disaggregation, which goes on alike in the river as in the lake, in ice still floating and in ice broken up.

Having observed some loose pieces of ice lying about, formed into needles like that which comes down from the lake, and knowing that these pieces were from the immediate neighbourhood of the place where they lay, I went to a spot where several men were employed cutting blocks for the summer provision of the inhabitants. These blocks, which are generally about four feet six inches or five feet long, and from two and a half to three feet broad, with a thickness of two feet, more or less, are placed endways in rows, to be forthwith taken away on sledges to different parts of the town. Upon examining these blocks, I found in them all, more or less, rows of very minute air-bubbles extending in straight lines, sometimes a little inflected, from the *upper surface* of the ice towards the lower, within from two to five inches of which they terminate. Other blocks presented these bubbles united, so as to form cylindrical canals, a little thicker than a horse-hair. Observing still further, I found blocks in which the process was more advanced, and two, three, or more clefts struck off in different directions from the vertical veins, so that a section perpendicular to the vein would represent in miniature the star-formed cracks of timber. Finally, in some pieces, these clefts united from top to bottom of the veins, separating the whole mass into vertical prisms, having a greater or less number of sides. In this state a slight shock was sufficient to detach them; and the block, with its scattered fragments, was in all respects the exact miniature resemblance, in crystal, of a Giants' Causeway. The surface was like a tessellated pavement, and the columns rose close, adhering and parallel, from the compact mass of a few inches at the under surface. More or less time is required for the process; which I have since seen in all its different stages. I have observed some in which the prisms (which are of all dimensions, from a few lines thick in some blocks, to an inch and upwards in others) are in curvilinear concretions, like certain species of actinolite. The prisms sometimes run one into the other, but are never articulated or fractured in a direction perpendicular to their axes. On the contrary, they even seem difficultly frangible in that direction, and when broken have a conchoidal fracture. They are moreover sonorous, consequently elastic, and consequently combined with a portion of caloric.*

This tendency to columnar disintegration seems inherent in the nature of the ice, and altogether independent of its position in or out of the water. Towards the latter part of the season, when the snow, in consequence of winds and thaws, has in a great degree disappeared from the surface, the ice on the river presents, in many places, a very remarkable appearance. The surface ice, clear and polished, is traversed in different directions by veins, sometimes meeting, though never crossing, and generally parallel to each other. The veins exactly resemble the veins of quartz which traverse gneiss, trap-rocks, &c. They vary in thickness from one to four and five inches, and exhibit regular and parallel fissures perpendicular to the direction of the veins. These veins, which vary in length from two to three or four feet, are nothing more than the sections of the flakes of ice turned on end on the first setting of the river. These flakes, which at first stick up irregularly in all directions above the surface of the water, get worn down by the elements during the winter to the level of the surface ice of the river, and in this state, though jammed in and forming a continuous mass with the surrounding ice, they undergo the same process of prismatic or columnar disintegration as that of the great blocks already mentioned; with this difference only, that in the veins the columns invariably reach from the one to the other surface.

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* Caloric seems to be the principle of all elasticity. That ice contains a notable portion of caloric has, however, been satisfactorily ascertained by many direct experiments.

It seems evident from this, that the process is entirely independent of air or gas rising from the water, and is probably owing to the arrangement of the particles of water in the process of congelation, and the subsequent changes induced by time and variation of temperature. This, however, is a mere conjecture; but considering how little the process of congelation is as yet understood, every observation on the subject of ice may be worthy the attention of the inquirer.*

Every traveller who has seen ice in large masses speaks with rapture of its colours. To some it is of a roseate hue; to others, emerald green; some describe it as being blue; others, as sea-green. I have examined the blocks on the Neva, in all directions, under all aspects of the sky, and at different times of the day, and have found the colour to be invariably the same when the ice is pure. It is then of a pale blue, inclining to aqua-marine green; if there be snow on one side, the blue is less visible, and the colour is sensibly greener. Examined closely, the blocks present innumerable cracks near the surface, which, like similar accidents in rock-crystal, refract the light into all the colours of the prism; the most predominant, however, is a rich and exquisitely beautiful sapphire blue, which, being softened by the distance, is probably the cause of the pale blue tint of the whole.

Were I to describe all the various and graceful or singular forms of congelation which may be here observed, there would be no end to this paper, already, I fear, too long. I shall, therefore, conclude by expressing my regret at not having been able to extend my observations further, and hoping that, such as they are, they may be found acceptable to those who study the physical part of geography.

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* Scoresby, speaking of the icebergs of Spitzbergen, says, "They are full of rents, as high as any of our people ascended them, extending in a direction perpendicularly downwards, and dividing them into innumerable columns. The surface was very uneven, being furrowed and cracked all over."

TABLE showing the Progress of Congelation of the Neva at St. Petersburgh, in the Winter of 1833-34.

Number of Observations.	Date.		Positive thickness of the ice.	Daily increase of thickness.	Increase of thickness since the first day.	Mean temperature for the time elapsed between each of the observations.	Difference of the mean temperatures.	Sum of the temperatures since the first day.	Thickness of *ice formed in the hole* from one observation to another.	REMARKS.
	D.	Hour.	Inch.	Inch.	Inch.	Deg. R.T.	Dg. R.T.	Deg. R.T.	In.	
	January.					°	°	°		
	9	$2\frac{1}{2}$ p.m.	$16\frac{7}{8}$	..	..	..	..	..	..	Starting point.
1	10	$1\frac{1}{2}$ p.m.	$17\frac{7}{8}$	1	1	-14,5	+1,0	- 14,5		
2	11	noon	$18\frac{4}{8}$	$\frac{5}{8}$	$1\frac{5}{8}$	-14,5	0,0	- 29,0		
3	12	noon	19	$\frac{4}{8}$	$2\frac{1}{8}$	-14,5	0,0	- 43,5	2,5	
4	14	noon	$20\frac{2}{8}$	$1\frac{2}{8}$	$3\frac{2}{8}$	-16,7	-2,2	- 60,2	5	Result of 48 hours.
5	15	$\frac{1}{2}$ p.m.	$21\frac{2}{8}$	1	$4\frac{3}{8}$	-17,3	-0,6	- 77,5	2,8	
6	16	noon	$21\frac{5}{8}$	$\frac{3}{8}$	$4\frac{6}{8}$	- 8,6	+8,7	- 86,1	..	Snow having fallen, the hole remained covered within, and was therefore prevented from freezing.
7	17	$\frac{1}{2}$ p.m.	22	$\frac{3}{8}$	$5\frac{1}{8}$	-13,8	-5,2	- 99,9	3	
8	18	noon	$22\frac{3}{8}$	$\frac{3}{8}$	$5\frac{4}{8}$	-12,1	+1,7	-112,0	1,1	Snow lying everywhere six inches thick.
9	19	$\frac{1}{2}$ p.m.	$22\frac{7}{8}$	$\frac{4}{8}$	6	- 8,6	+3,5	-120,6	1,2	
10	20	noon	23	$\frac{1}{8}$	$6\frac{1}{8}$	- 0,6	+8,0	-121,2	..	No ice in the hole, it being a thaw.
11	21	noon	23	..	..	+ 0,2	+0,8	-121,0	..	Idem.
12	22	$\frac{1}{2}$ p.m.	23	..	..	- 4,8	-5,0	-125,8	1,3	More snow had fallen, but not till after the surface ice had been formed.
13	23	noon	$23\frac{1}{8}$	$\frac{1}{8}$	$6\frac{2}{8}$	- 6,2	-1,4	-132,0	..	Orifice filled with snow; no surf. ice.
14	24	$\frac{1}{2}$ p.m.	$23\frac{2}{8}$	$\frac{1}{8}$	$6\frac{3}{8}$	- 9,2	-3,0	-141,2	..	Idem.
15	26	$\frac{1}{2}$ p.m.	24	$\frac{6}{8}$	$7\frac{1}{8}$	-15,3	- 6,1	-156,5	3	Result of 48 hours. The three inches of surface ice here indicated was rather compressed snow than real ice; it was opaque and dingy.
16	27	noon	$24\frac{5}{8}$	$\frac{5}{8}$	$7\frac{6}{8}$	-18,5	-3,2	-175,0	3	The cake of ice of the orifice covered with beautiful foliated concretions of snow; the thick transparent ice round the hole exhibiting fine air-tubes, finer than a hair, and converging from the periphery towards the centre; cracks, occasioned by percussion, refracting the most beautiful sapphire-blue, and innumerable irises, like those of quartz.
17	28	noon	$25\frac{2}{8}$	$\frac{5}{8}$	$8\frac{3}{8}$	-19,3	-0,8	-194,3	3,2	
18	29	noon	26	$\frac{6}{8}$	$9\frac{1}{8}$	-12,3	+7,0	-206,6	2	
19	30	noon	$26\frac{4}{8}$	$\frac{4}{8}$	$9\frac{5}{8}$	- 9,6	+2,7	-216,2	0,9	Surface in general covered with seven inches of snow.
20	31	noon	$26\frac{6}{8}$	$\frac{2}{8}$	$9\frac{7}{8}$	-12,4	-2,8	-228,6	2,6	
	February.									
21	1	noon	$27\frac{1}{8}$	$\frac{3}{8}$	$10\frac{2}{8}$	-15,6	-3,2	-244,2	2,9	
22	2	noon	$27\frac{4}{8}$	$\frac{3}{8}$	$10\frac{5}{8}$	-11,9	+3,7	-256,1	2	
23	5	$\frac{1}{2}$ p.m.	$28\frac{4}{8}$	1	$11\frac{5}{8}$	- 8,8	+3,1	-264,9	1,7	Result of 72 hours.
24	6	$\frac{1}{2}$ p.m.	$28\frac{7}{8}$	$\frac{3}{8}$	12	-15,7	- 6,9	-280,6	2,5	
25	7	noon	$29\frac{2}{8}$	$\frac{3}{8}$	$12\frac{3}{8}$	- 6,8	+8,9	-287,4	1,6	
26	8	noon	$29\frac{4}{8}$	$\frac{2}{8}$	$12\frac{5}{8}$	-10,8	-4,0	-298,2	3,2	One-half of the thickness of the ice in the hole transparent, the other opaque.
27	9	noon	$29\frac{5}{8}$	$\frac{1}{8}$	$12\frac{6}{8}$	-10,2	+0,6	-308,4	2,7	
28	10	$\frac{1}{2}$ p.m.	30	$\frac{3}{8}$	$13\frac{1}{8}$	- 6,3	+3,9	-314,7	0,5	Much snow had fallen during the last 24 hours.
29	11	1 p.m.	$30\frac{1}{8}$	$\frac{1}{8}$	$13\frac{2}{8}$	- 6,4	-0,1	-321,1	1,1	Snow lying a foot deep everywhere.
30	12	$\frac{1}{2}$ p.m.	$30\frac{3}{8}$	$\frac{1}{8}$	$13\frac{3}{8}$	- 9,4	-3,0	-330,5	1,8	
31	13	$\frac{1}{2}$ p.m.	$30\frac{6}{8}$	$\frac{3}{8}$	$13\frac{6}{8}$	-11,1	- 1,7	-341,6	2	
32	14	$\frac{1}{2}$ p.m.	31	$\frac{2}{8}$	14	-13,6	-2,5	-355,2	2,7	
33	16	noon	$31\frac{5}{8}$	$\frac{5}{8}$	$14\frac{5}{8}$	-12,4	+1,2	-369,6	4	Result of 48 hours.
34	17	noon	$31\frac{5}{8}$	..	..	- 3,0	+9,4	-370,0	..	Orifice filled with snow, and no ice formed.
35	18	noon	$32\frac{3}{8}$	$\frac{6}{8}$	$15\frac{3}{8}$	- 0,6	+2,4	-370,6	..	No ice nor snow in the orifice, it being a thaw.
36	27	$\frac{1}{2}$ p.m.	$32\frac{4}{8}$	$\frac{1}{8}$	$15\frac{4}{8}$	- 1,4	-0,8	-372,0	2	Of the nine preceding days, eight were a great thaw, which rendered it impossible to pass on the ice for the melted snow, but with inconvenience. The two-tenths of ice in the hole, as also the one-eighth increase of the main ice, entirely due to the cold of the last 24 hours.
37	28	noon	$32\frac{4}{8}$	..	..	+ 0,8	+2,2	-371,2	3	
	March.									
38	1	noon	$32\frac{5}{8}$	$\frac{1}{8}$	$15\frac{5}{8}$	- 2,6	-3,4	-373,8	1,4	
39	2	noon	$32\frac{5}{8}$	..	..	- 3,3	-0,7	-377,1	1,7	
40	3	noon	$32\frac{5}{8}$	..	..	- 1,5	+1,8	-378,6	1,2	
41	4	2 p.m.	$32\frac{5}{8}$	..	..	- 5,6	-4,1	-384,2	2,3*	

* The indications of this column are in inches and tenths of an inch.

TABLE showing the Temperature of the Neva at different Depths, the River being Frozen Over.

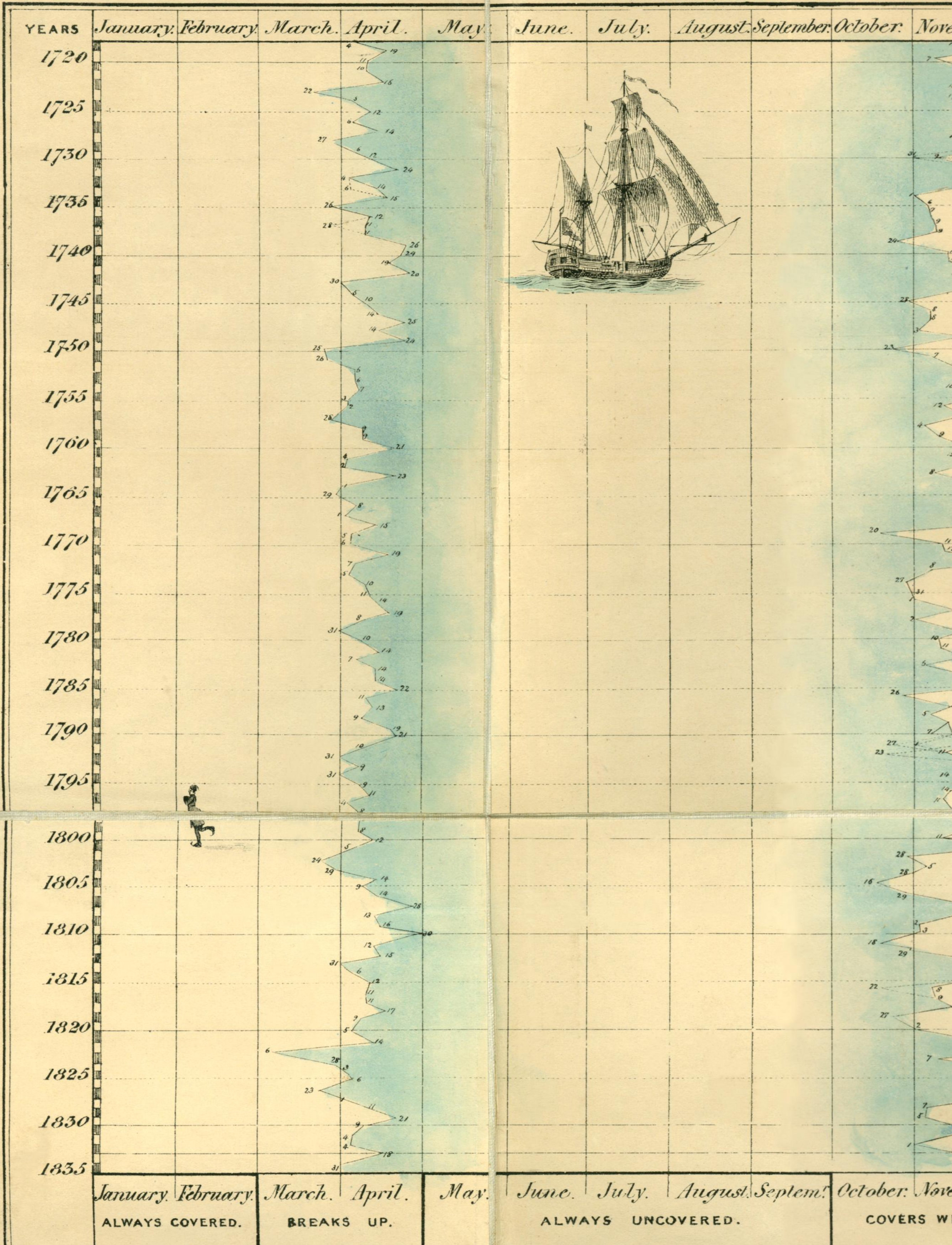
Number of Observations.	Depth.	Date of Observation. Instrument Let down, Month of March, 1834.		Date of Observation. Instrument Taken up, Month of March, 1834.		Instrument remained down.	Thermometer, No. 212. Indication at the moment of letting down.	Thermometer, No. 212. Indication when drawn up, or temperature of the water at the given depth.	Therm. No. 202. Temperature at the surface.	Therm. No. 206. Temperature of the air at the moment of taking up the instrument from the bottom.	Mean atmospheric temperature of the 24 hours preceding the taking up of the instrument, as observed at the Academy of Sciences, a few paces from the place of observation.	Time employed in drawing up the instrument.	REMARKS.
	Feet.	Day.	Hour.	Day.	Hour.	Hours.	Deg. R. T.	Deg. R. T.	Deg. R. T.	Deg. R. T.	Deg. R. T.	Seconds.	
1	34	8	7 a.m.	—	5 p.m.	10	+ 0·12	+ 0·12	Zero	+ 1·12	+ 1·3	45	This depth is that of the bottom of the river, *minus* 1 foot, the height of the suspended weight preventing the instrument from touching the soil.
2	idem	9	6 a.m.	—	5 p.m.	11	+ 0·12	+ 0·12	id.	+ 1·31	+ 0·2	30	
3	idem	10	6¼ a.m.	—	5 p.m.	10¾	+10·58	+ 0·07	id.	− 4·37	− 2·9	30	
4	idem	10	5 p.m.	11	5½ p.m.	24½	+ 0·07	+ 0·02	id.	− 5·65	− 5·9	26	
5	18	12	7 a.m.	—	5½ p.m.	10½	+ 8·44	+ 0·02	id.	− 5·26	− 7·5	18	
6	28	13	7 a.m.	—	5¼ p.m.	10¼	+ 4·99	+ 0·02	id.	− 3·20	− 6·5	20	
7	14	13	5¼ p.m.	14	5 p.m.	23¾	+ 0·02	Zero	id.	− 0·35	− 3·7	10	
8	7	15	½ p.m.	16	4½ p.m.	16	+ 4·28	Zero	id.	− 0·22	− 1·7	3	
9	34	17	4½ a.m.	18	4 p.m.	23½	+ 9·28	+ 0·02	id.	− 4·30	− 5·1	30	Temperature of 48 hours.
10	28	18	4 p.m.	19	4½ p.m.	24½	+ 0·02	+ 0·07	id.	+ 0·33	− 3·4	12	Idem.
11	21	19	4½ p.m.	20	4½ p.m.	24	+ 0·07	+ 0·04	id.	+ 0·51	− 1·2	10	
12	14	20	4½ p.m.	21	4½ p.m.	24	+ 0·04	+ 0·04	id.	− 1·33	− 2·2	6	
13	7	21	4½ p.m.	22	5 p.m.	24½	+ 0·04	Zero	id.	− 2·70	− 3·6	3	
14	28	22	5 p.m.	23	4½ p.m.	23½	Zero	+ 0·07	id.	− 3·40	− 4·4	14	
15	14	23	4½ p.m.	24	5 p.m.	24½	+ 0·07	+ 0·02	id.	− 1·33	− 3·5	7	
16	28	24	5 p.m.	25	5 p.m.	24	+ 0·02	+ 0·07	id.	− 1·53	− 3·5	15	
17	14	25	5 p.m.	26	5½ p.m.	24½	+ 0·07	+ 0.02	id.	− 1·00	− 4·1	8	
18	34	27	4¼ p.m.	28	4¼ p.m.	24	+10·27	+ 0·08	id.	− 2·31	− 3·8	25	The rope being frayed, obliged to take up the instrument.
19	18	28	4¼ p.m.	29	5 p.m.	24¾	+ 0·08	+ 0·08	id.	+ 1·12	− 2·7	15	Temperature of 48 hours.
20	21	29	5 p.m.	30	4¼ p.m.	23¼	+ 0·08	+ 0·04	+ 0·02	+ 4·11	+ 3·4	16	
21	28	30	4¼ p.m.	31	½ p.m.	20¼	+ 0·04	+ 0.06	Zero	+ 3·42	+ 1·7	20	

Recapitulation . . . .

Depth.	No. of Observations.	Medium Temperature.
Surface . . .	21	0·00
At 7 feet . . .	2	0·00
At 14 id. . . .	4	+ 0·02
At 18 id. . . .	2	+ 0·05
At 21 id. . . .	2	+ 0·04
At 28 id. . . .	5	+ 0·058
At 34 id. bottom	6	+ 0·055

CHRONOLOGICAL TABLE of the FREEZING and OPE

FOR 116 YEARS, FROM 1718 TO 1834



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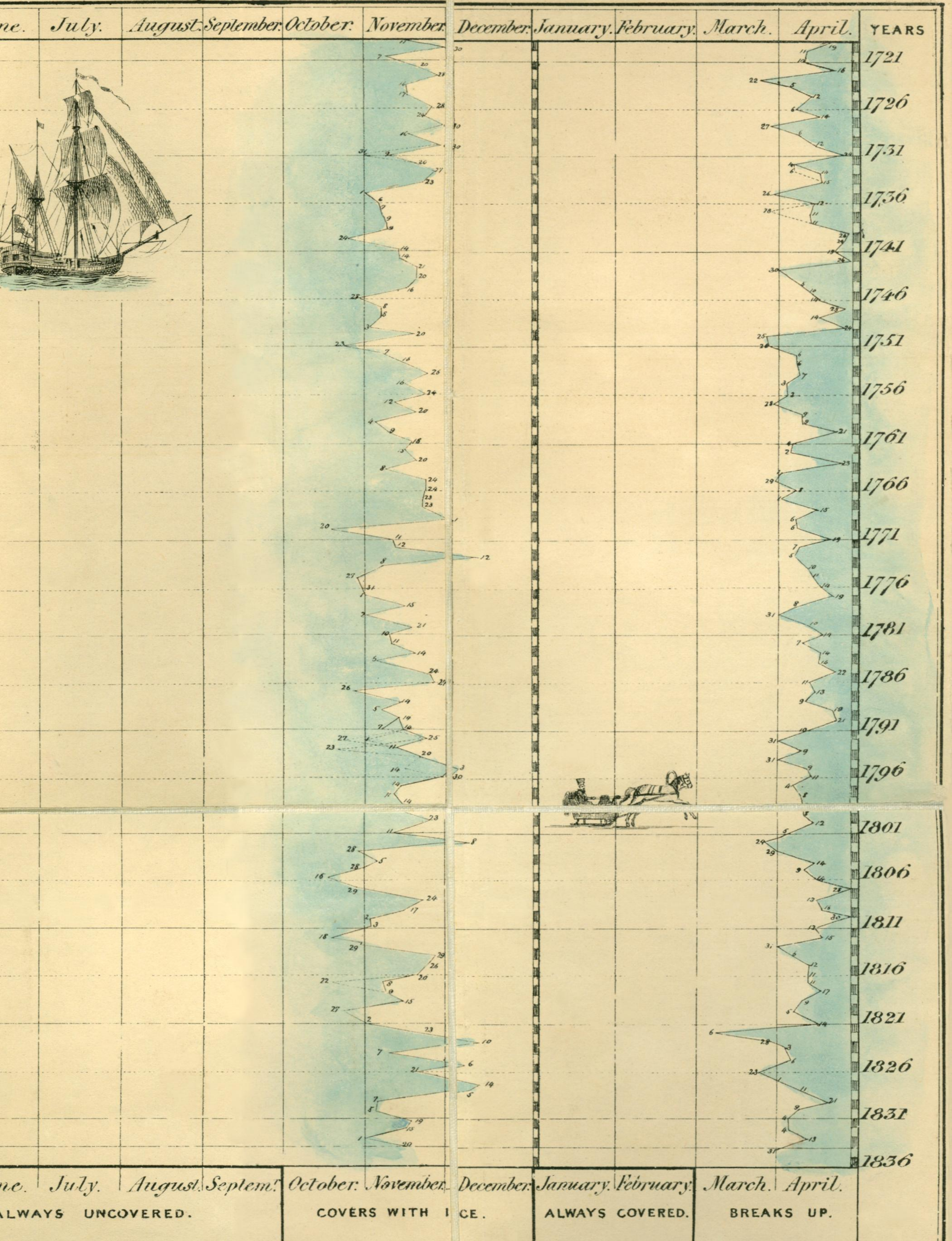
# of the FREEZING and OPENING of the RIVER NEVA.

FOR 116 YEARS, FROM 1718 TO 1834.



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C. Bradbury